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Research Article

An Instigation to Green Manufacturing: Characterization and Analytical Analysis of Textile Wastewater for Physico-Chemical and Organic Pollution Indicators

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Abstract

Severe environmental pollutions are contributed by textiles at an alarming rate. Proper treatment of wastewater before discharge is mandatory for maintain our ecological balance. Pollution levels of textile effluent has been investigated and analyzed in this research. Effluent samples from different areas of textile processing industries in Bangladesh were collected and analyzed. A total forty sample were studied and characterized their result ranged are temperature, pH, Total Dissolved Solid (TDS), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Biological oxygen demand (BOD_5). Standard sample collection procedures was followed to collect samples of six months and analyzed immediately temperature, pH & TDS by pocket size Thermometer, pH and TDS meter. To sum up, textile effluent contains high Temperature, pH, TDS, COD and lower DO which threatens aquatic lives live. It has been acclaimed that, it is quite unsafe for this discharge into water body to continue. The ecological and human health safety of continual discharge of this textile effluents into surface water are undoubtedly under threat.

Keywords: Textile Effluent; Green manufacturing; Organic pollution indicators; Environmental impact

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1. Introduction

There are various types of textile wet processing plants e.g., the woven dyeing plants and, Knit dyeing plants, Yarn and garments Dyeing plants. The wastewater produced by the textile industry is the most polluting among all industrial sectors [1]. Effluent from the textile industry commonly contains high concentrations of organic and inorganic chemicals and are characterized by high Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Dissolved Solids (TDS), pH, Total Suspended Solids (TSS) values and low Dissolved Oxygen (DO) value as well as strong color. The major concern with color is its aesthetic character at the point of discharge with respect to the visibility of the receiving waters [2]. In the near future, consumers will issue stricter standards on colored waste streams. It is likely that Textile industries will be forced to remove residual dyestuffs from wastewater before discharging them into receiving waters [3]. The presence of TDS in water may affect its taste. High hardness in conjunction with high alkalinity or sulfates causes scale. A laxative effect can be caused by high sulfate content. Abnormally high or low dissolved solids disturb osmotic balance of native species. Disposal of the salt laden effluents into ground and surface water bodies cause pollution and render them unfit for domestic, industrial and agricultural use. High salt concentration interferes with proper operation of biological wastewater treatment plant. In the dyeing and finishing processes a considerable amount of effluent is generated, which is very toxic and contains strong color, a large amount of suspended solids, a highly fluctuating pH, high temperature, COD, BOD etc. [4]. Because of these characteristics, treatment of textile wastewater is an essential requirement before it is being disposed to natural water system [5]. There are many methods of effluent treatment such as, ion exchange [5], coagulation and flocculation [6], oxidation [7], reverse osmosis [8], biological decolonization [9] and adsorption [10] to reduce pH, color and TDS from textile effluent. The effluent generated in different step or processes is well beyond the standard and thus it is highly polluted and dangerous [6]. For treatment of textile wastewater there are three types of effluent treatment plant as follows. Biological treatment Plant, Physico-chemical Treatment plant, Bio-chemical treatment plant [7-9]. Among them Biological treatment plant is widely used for it simple operation and better water quality with lower cost. Several chemical and physicochemical reactions requires in biological effluent treatment plant includes oxidation, synthesis and Endogenous Respiration.

Oxidation process

COHNS + O_2 + Bacteria + DAP and UREA CO_2 + NH_3 + Energy + Other end Products

DAP and Urea is used as food for the microorganism.

Synthesis Process

COHNS+O_2+ Bacteria $C_5H_7NO_2$ (New bacteria)

Endogenous Respiration

$$C_5H_7NO_2 + 5O_2 \longrightarrow CO_2 + NH_3 + 2H_2O$$

Apart from the above basics reaction there are some other reactions that take place in the MBBR reaction tanks. During aeration the oxygen reacts with C, S and N which is shown below;

$$C + O_2 \longrightarrow CO_2$$
$$S + O_2 \longrightarrow SO_2$$
$$N + O_2 \longrightarrow NO_2$$

Some untreated ferrous sulphate and ferrous hydroxide reacts with oxygen and the reactions are as follows,

$$FeSO_4 + O_2 \longrightarrow Fe_2(SO_4)_3$$
$$Fe(OH)_2 + O_2 \longrightarrow Fe(OH)_3$$

While most of the activated sludge is recycled some may be surplus to requirements and needs to be disposed as does detached biofilm from film reactor. The treated liquid is discharged to the environment or taken for further treatment depending on the desired standard of effluent quality or the required use of the wastewater.

Effluent discharge standards

Wet processing of textiles involves, in addition to extensive amounts of water and dyes, a number of inorganic and organic chemicals, detergents, soaps and finishing chemicals to aid in the dyeing process to impart the desired properties to dyed textile products. Residual chemicals often remain in the effluent from these processes. In addition, natural impurities such as waxes, proteins and pigment, and other impurities used in processing such as spinning oils, sizing chemicals and oil stains present in cotton textiles, are removed during scouring and bleaching operations. This results in an effluent of poor quality, which is high in BOD and COD load. Table 1 lists typical values of various water quality parameters in untreated effluent from the processing of fabric using reactive, sulfur and vat dyes and compares these to the DOE effluent standards for discharge into an inland surface water body (e.g. river, lake, etc.). As demonstrated, the effluent from textile industries is heavily polluted [10-11]. Effluent Characteristics of untreated Effluent from Processing Of fabrics using Reactive, Sulpher, reactive and vat Dyes Standards [4, 12-14].

Table 1: Standards for waste from industrial units or project waste- for island Surface water Discharge

Parameters	*DOE Standards For waste from industrial units or project waste- for island Surface water Discharge*
Appearance	-
pH	6-9
Color	-
Heavy Metal	Varies Depending on types of metal.
Suspended Solids	150
Total Dissolved Solids	2100
Chemical Oxyzen Demand (COD)	200
Biochemical Oxyzen Demand (BOD)	50
Oil & Grease	10
Surfactants	-
Sulphide as S	1

2. Experimental

2.1 Materials

Effluent water for this research was collected from different industrial areas and analyzed as separate sample. In this area's most of the industries processed mostly cotton fabrics. The main products of the factory are Dyed fabric and Dyed yarn. Various departments carry out different operations and produces different type of wastewater. The cotton textile mill has three main departments: first, a spinning department, where the fibers are spun into yarns. Second, the weaving department, where the yarns are converted to grey fabrics. The third department is the wet processing consisting of Kier boiling, bleaching, mercerizing, dyeing, finishing and prints work. The effluent obtained here arise mainly from the Kier boiling, bleaching and the dye-house processes.

Figure 2 Textile Effluent Sample Collection

2.2 Chemicals and Testing Instruments

Pocket Sized TDS Meter with a range of 100 / 1000 ppm, Model number HI 96302, Manufactured by Hanna Instruments, Country of Origin is Italy was used to measure TDS. The TDS meter has been calibrated by a standard solution (1382 mg/L) as per operation manual of manufacturer. Pocket sized pH Meter of Model number HI 96107, Manufactured by Hanna Instruments, Country of Origin is Italy used to analyze pH. The pH meter has been calibrated by three buffer solutions (pH = 7, pH = 4 and pH = 10) as per suggested method in operation manual of manufacturer. To measure temperature, laboratory thermometer was used. DO, COD, and BOD_5 was analyzed in third party testing institute.

2.3 Methodology

To conduct this research, all sample effluent were collected by standard sampling procedure. The samples were prepared and marked for characterization. Color, Odor, temperature, pH, TDS has been investigated in Southeast University laboratory. To characterize DO, COD, BOD_5 the marked samples were sent to third party testing institute and cross checked and analytical analysis has been carried.

Determination of Temperature and pH

Temperature of each sample was determined by glass-in-mercury thermometer. Immediately after collection of the samples pH was determined with an electric pH meter (pH Hanna Instrument Ltd., UK). For soil and sediment sample, 10 gm of the sample mixed thoroughly with 20 ml of distilled water (1:2), and the pH was determined pH by meter

Determination of TDS

TDS in the effluent samples were determined by filtering 100 ml sample through a Whatman No. 42 filter paper to retain fine crystalline particles. The filtrate was transferred onto the evaporating dish and placed on water bath at 100 ℃ until all the liquid had evaporated, leaving behind on the solid remains. The dish was then placed in an oven at 100 ℃ for 2 hrs, and then cooled in desiccators for 30 minutes. The process of drying and cooling was carried out repeatedly, in the same manner, until a constant weight was acquired.

Determination of BOD_5

BOD of the effluent samples was determined by Winkler method. The assay was carried out by the measurement of dissolved oxygen content of the samples before and after 5 days of incubation at 20 ℃. The sample was freed from residual chlorine using $NaSO_4$.

Determination of COD

COD of the effluent samples was determined by the Open Reflux method. After refluxing the sample with a known amount of standard potassium dichromate ($K_2Cr_2O_7$), the amount of dichromate consumed was found out by back titration with standard ferrous ammonium sulfate [$(Fe(NH_4)_2(SO_4)_2.6H_2O)$] (Mohr salt) and sulfuric acid (H_2SO_4), respectively in the presence of silver sulfate as catalyst. A blank was also run simultaneously. Solution. Four times dilution of the sample were made in order to get the depletion in the range of 40% to 70%. The dilution water was prepared by aerating (bubbling compressed air) for 1-2 days to attain dissolved oxygen saturation.

3. Results and Discussion

Processing of textiles materials involves use of extensive amounts of water and dyes, a number of inorganic and organic chemicals, detergents, soaps and finishing chemicals to aid in the dyeing process to impart the desired properties to dyed textile products. Residual chemicals often remain in the effluent from these processes. In addition, natural impurities such as waxes, proteins and pigment, and other impurities used in processing such as spinning oils, sizing chemicals and oil stains present in cotton textiles, are removed during, scouring and bleaching operations. This results in an effluent of poor quality, which is high in BOD and COD load.

3.1 Analytical characterization of textile effluents

Different areas of textile processing industries produces different kinds of products, among them most of the industry process cotton, polyester, nylon. Effluent collected from these areas are characterized. Table 2 displays the result of analytical investigation of textile effluent.

It has been clearly seen that, the color of effluent were mainly found in black, reddish, bluish, greenish. Among all samples most of samples contains black color, some other were found in Greenish and

Bluish respectively. As processing industries used red, yellow and blue as primary color for textile coloration. Prominence of this three color was noticed in effluent. After comprehensive analysis it comes to light that, about majority amount of sample were foul in odor and a good number was pungent whereas least found as odorless.

Table 2 Analytical characterization of textile effluents

Sl.	Color	Odor	Temp (^{0}c)	pH	TDS (mg/l)	DO (mg/l)	COD (mg/l)	BOD_5 (mg/l)
1	Black	Odor less	32	7.8	2360	5.81	309	10
2	Black	Odor less	27.5	7.2	2218	2.8	312	28
3	Black	Foul	35	10.2	2713	4.6	308	108
4	Black	Foul	33	10.1	2699	3.2	301	98
5	Reddish	Foul	36	10.4	2909	2.13	323	126
6	Bluish	Pungent	28.5	8.9	2308	4.3	359	90
7	Bluish	Foul	27	10.2	2709	5.4	338	102
8	Black	Pungent	27	10.3	2603	3.27	306	110
9	Greenish	Pungent	30	9.2	2631	2.15	302	124
10	Greenish	Foul	28.5	10.6	2703	4.32	308	88
11	Greenish	Pungent	29	9.6	2821	5.41	312	112
12	Greenish	Foul	29.5	9.8	2938	2.73	359	123
13	Black	Pungent	30	10.5	2818	2.10	302	108
14	Bluish	Pungent	28.5	9.5	2796	3.42	359	112
15	Bluish	Foul	29.5	10.1	2609	2.03	338	132
16	Black	Pungent	28	9.6	2594	3.91	306	145
17	Black	Pungent	29	10.3	2545	2.82	312	97
18	Bluish	Pungent	31.5	11.3	3012	1.95	308	111
19	Black	Foul	28.5	10.8	2503	2.03	301	99
20	Greenish	Pungent	31	10.7	2370	3.27	323	109
21	Greenish	Pungent	30.5	10.6	2874	2.51	359	112
22	Blusih	Foul	29	10.5	2983	4.16	306	129
23	Black	Pungent	29.5	10.9	2509	3.86	302	84
24	Black	Foul	30	10.3	2456	3.14	308	76
25	Bluish	Foul	30	9.8	2708	4.11	312	89
26	Black	Foul	31	10.2	2615	2.03	359	35
27	Greenish	Pungent	31.5	9.6	2374	2.12	323	96
28	Greenish	Foul	33.5	10.6	2874	3.24	359	123
29	Black	Foul	32.5	10.4	2914	2.58	306	126
30	Black	Foul	32	9.8	2598	3.78	302	114
31	Black	Pungent	29	9.6	2821	5.41	323	88
32	Greenish	Foul	29.5	9.8	2938	2.73	302	70
33	Greenish	Pungent	30	10.5	2818	2.1	312	65
34	Black	Pungent	28.5	9.5	2796	3.42	323	106
35	Bluish	Foul	29.5	10.1	2609	2.03	312	110
36	Bluish	Pungent	28	9.6	2594	3.91	359	104
37	Black	Pungent	29	10.3	2545	2.82	323	109
38	Black	Pungent	31.5	11.3	3012	1.95	302	60
39	Bluish	Foul	28.5	10.8	2503	2.03	312	67
40	Black	Pungent	31	10.7	2370	3.27	323	91

Temperature

Figure 3 (left) describes the temperature variation of effluent based on different samples. Dischargeable effluent temperature under effluent discharge standard is about 30 ^{0}C [4, 12]. Average temperature of effluent investigated is about 32 ^{0}C. Figure 3(right) describes that about 35 samples out of 40 samples found in temperature ranges of 28 ^{0}C to 32 ^{0}C. Where only three sample found in temperature bellow 28^{0}C where more two samples found in temperature of 33 ^{0}C to 38 ^{0}C. So this analysis indicates proper temperature treatment before releasing into water body.

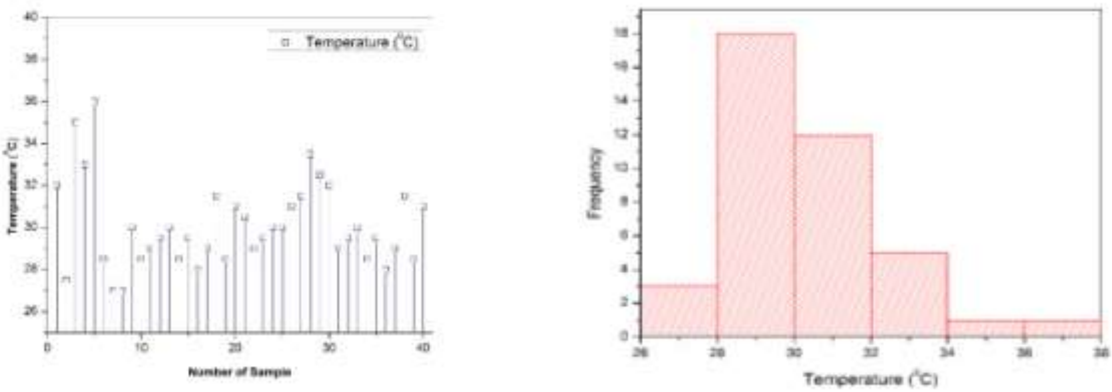

Figure 3: (left) temperature of effluent water, (right) Histogram analysis of samples

pH

The effluent discharge standard allows pH 6 to pH 9 as dischargeable in inland surface water [4, 12]. Figure 4(left) shows the result of pH analysis in textile effluent. It has been shown that, the pH of textile effluent found from 7.20 to 11.30 on different areas. According to figure 4(right) demonstrates that, about thirty-two sample effluent sample contains pH ranges from 9.5 to 11.0 where only six sample was found within discharge limit. Others have pH of more than 11.0.To process cotton with reactive dyes enormous amount of alkali used as electrolyte. A large amount of alkali discharge with effluent thus responsible for increase of pH. Thus indicates effluent treatment before releasing to inland surface water.

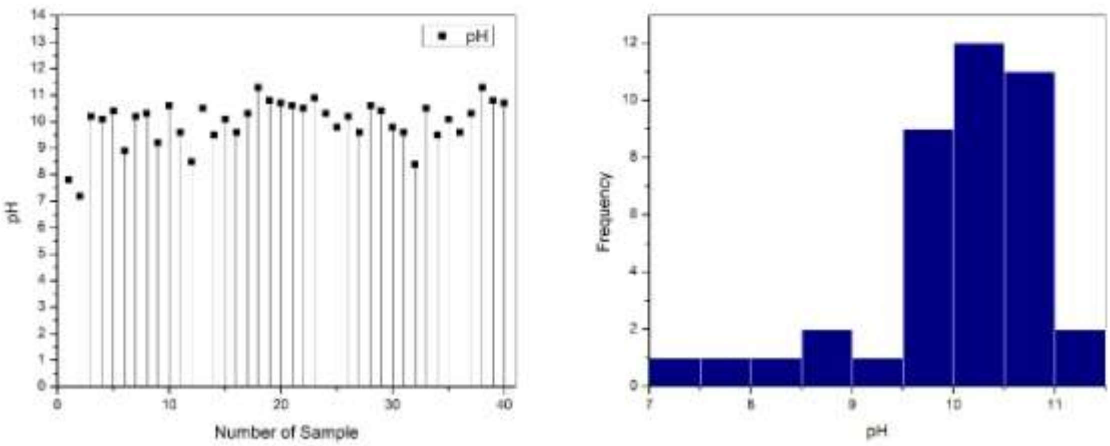

Figure 4 (left) pH analysis of effluent water, (right) Histogram analysis of samples

Total Dissolved Solid (TDS)

Upon analysis of experimental data, Total dissolved solid (TDS) of all samples were found in a range of 2218 mg/l to 3012 mg/l. The average TDS found 2669.25 mg/l. The dischargeable standard for effluent for TDS is 2100 mg/l [4, 12]. Figure 5(right) shows analytical result of TDS (mg/l). Figure 5(left) describes the frequency of TDS of all tested samples, where it can be seen that samples found in TDS more than 2500 mg/l to 3000 mg/l. So it's pointing proper treatment textile effluent before releasing to surface water body.

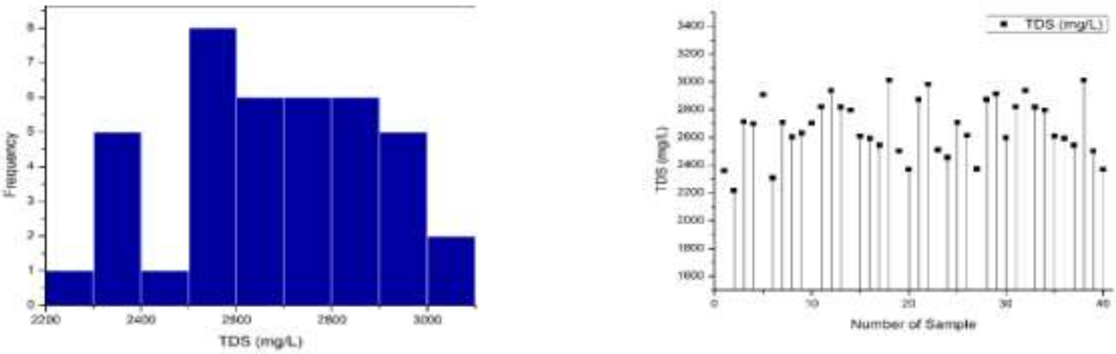

Figure 5 (right) Analytical TDS analysis of effluent water, (left) Histogram analysis of samples

Dissolved oxygen (DO)

Without sufficient amount of oxygen, aquatic life cannot survive. This effluent discharge standards indicated that, effluent must contains 4.5 to 6.0 mg/l of dissolved oxygen before discharge into surface water body [4, 12]. From figure 6(right) it can be seen that, textile effluent contains a range staring from 1.95 mg/l to 5.83 mg/l dissolved oxygen which is alarming for aquatic life. Figure 6 (left) shows histogram DO analysis of effluent water, it can be seen that, maximum ten samples found having DO of 2mg/l to 2.50 mg/l where total 23 sample shows DO of 2.50 mg/l to 4.50 mg/l. As per discharge standard the minimum DO should be 4.50 mg/l. It can be seen that, only 4 sample found in dischargeable limit.

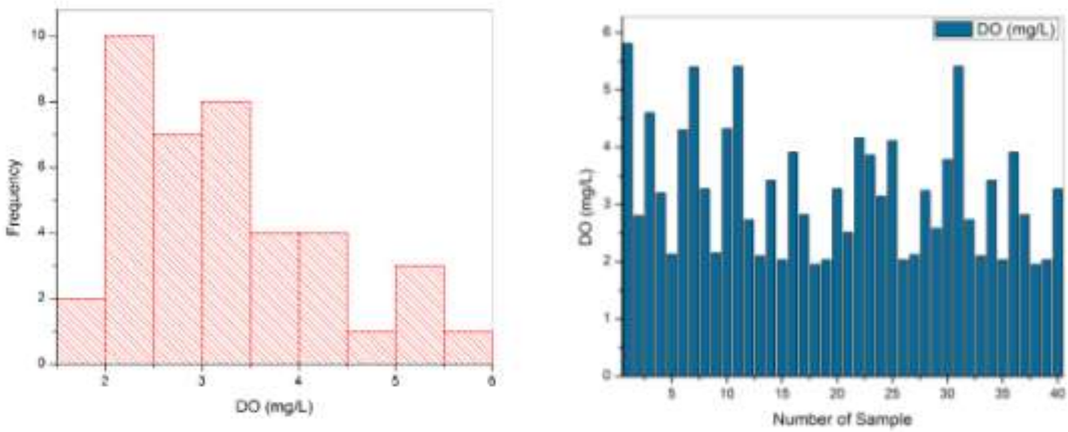

Figure 6 (right) DO analysis of effluent water, (left) Histogram analysis of samples

Chemical Oxygen Demand (COD)

Chemical oxygen Demand for textile effluent for samples were found between 301 mg/l to 359 mg/l. An analytical analysis is shown in figure 7 (left. Analysis shows that, Lowest COD of among all sample is much higher than effluent discharge standard for COD (200 mg/l) [4, 12]. Figure 7(right) shows that, no sample found which has COD level near about discharge standard. A total 17 sample found in COD range of 300 mg/l to 310 mg/l. 7 samples found in COD value of 310 mg/l to 320 mg/l, 320 mg/l to 330 mg/l and 350mg/l to 360 mg/l respectively.

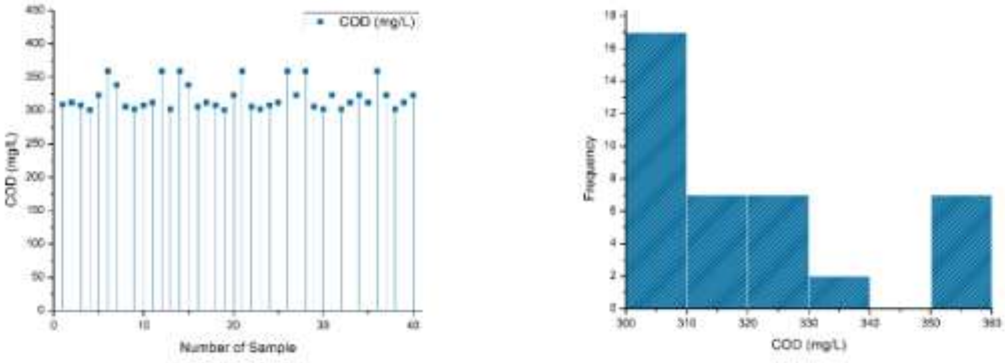

Figure 7 (a) Analytical COD analysis of effluent water, (b) Histogram analysis of samples

Biological Oxygen Demand (BOD_5)

Comprehensive analysis shows that, Biological oxygen demand of textile effluent of different areas fluctuated roughly. This can be happed due to the type of material process and nature of chemical and utilities used. Figure 8(right) shows that, the highest BOD_5 found is a value of 145 mg/l and lowest was found 10 mg/l. On the other hand, from figure 8(left) is has been indicated that, BOD_5 of most of the samples lies between 60 mg/l to 140 mg/l where highest 14 samples found in 100mg/l to 120 mg/l. The discharge limit of BOD_5 under department of environment is 50mg/l [4, 12]. So the investigation leading a must needed treatment of textile effluent before releasing into surface water body to reduce bad impact on ecological balance.

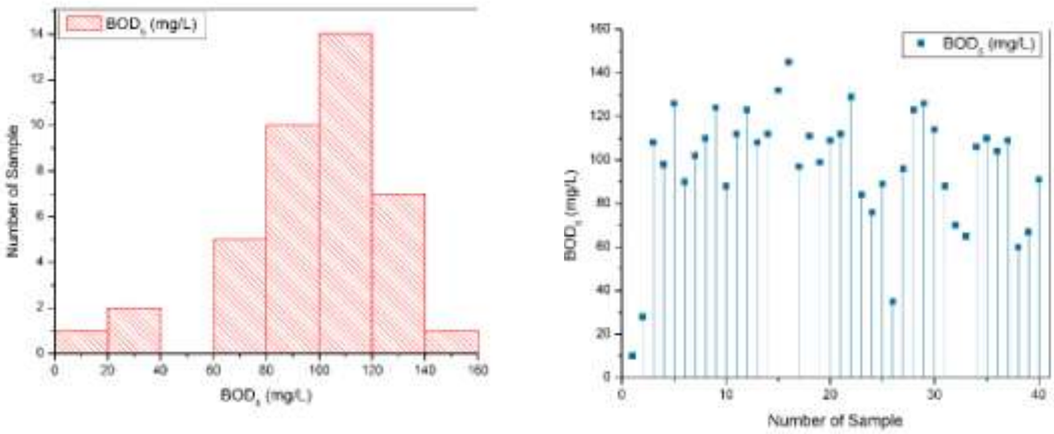

Figure 8 (a) BOD_5 analysis of effluent water, (b) Histogram analysis of samples

Impact of textile effluent on Environment

Environmental problems and potential hazards caused by industrial wastewater has prompted many countries to limit the discharge of polluting effluent in receiving waters. Textile manufacturing yields a large quantity of colored and highly toxic wastewater. The reported values lie beyond the permissible limits set by the National Environmental Quality Standard. At present about 75% of wastewater generated from municipal and industrial sources are being discharged into the surface water without proper treatment. Generally, the textile industries are contributing relatively high quantity of problematic compounds in the environment, as most of removed before discharge into the water stream. them have either no treatment facilities or have grossly inadequate arrangements. Among all pollutants, color in textile effluent is the main pollutant. The results of physicochemical variables of the water sample shows that, together with the limit values accepted by the regulatory authority, the water sample's pH, temperature, BOD5, COD and DO levels were found to be higher than the limit values, hence violating the discharge limits. The highest biochemical oxygen demand (BOD_5) was 145 mg/L; COD 359 mg/l, DO 5.83 mg/L; and TDS 3012 mg/L which are causes for several ecological imbalance [15-16]. These compounds contaminate the surface water, thereby making it unfit for irrigation and drinking. Therefore, proper treatment of effluent water and enforcement of pollution control by the regulatory authority on the indiscriminate discharge of textile wastewater into water bodies should be carried out.

Since farmers are using water from river for agricultural purposes and the residents of the town are using both the surface and underground waters from the same area as potable water, it is quite unsafe for this discharge into this water body to continue. The ecological and human health safety of continual discharge of this treated textile effluents into surface water are undoubtedly under threat.

4. Conclusion

Dyeing of the different fibers are somewhat different and each of them requires a different class of dye. Different dyestuffs require different types of chemicals and auxiliaries to apply them into the fabric or textile product. As a result the characteristics of the textile waste water vary significantly. Due to variation of characteristics, textile waste water requires various types of techniques to treat them. However, this work mainly investigated the most important measures of water like, Temperature, pH, TDS, COD and DO of ten different samples. Heavy metals, metal, iron and chloride need to investigate. In this work the Temperature, pH, TDS, COD and DO values of textile wastewater found create concern of proper treatment of effluent before releasing to surface water body.

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